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DEFENSE SPENDING AND HIGH TECHNOLOGY DEVELOPMENT: NATIONAL AND STATE ISSUES

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Summary

One argument used by critics of the significant increases in U.S. defense spending in the 1980s is that this growth has undermined the international economic position of the United States by diverting resources from the development of commercial product and process technologies to military applications. Lynn Browne, a vice president in the research department of the Federal Reserve Bank of Boston, examines this proposition in the following study. The author finds scant cause and effect between the rise in defense expenditures and the declining international competitiveness of U.S. industry.

Introduction

The impact of defense spending on the economy has long been a subject of debate; however, the debate intensified in the early 1980s in response to President Reagan's proposed defense buildup. The adverse economic consequences that have been attributed to defense spending are many and diverse, encompassing fears that rising defense expenditures lead to inflationary pressures as well as concerns about the distributional consequences of defense spending for some occupational and socioeconomic groups. One criticism heard with greater frequency in the 1980s is that defense spending undermines the competitiveness of U.S. industry.

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Expenditures for defense account for a much larger fraction of GNP in the United States than in most of its trading partners. These expenditures, it is argued, have diverted resources from activities that would have better served the cause of U.S. competitiveness. In particular, they have undermined U.S. technological leadership, in that research and investment dollars and professional and technical personnel have been devoted to defense purposes rather than to developing new and superior products and to improving manufacturing processes. Our trading partners, without the same defense burden, have been able to concentrate their resources on commercial applications with the result that in an increasing array of industries they challenge the United States in productivity and quality of goods produced.

Contrasting with this view of defense spending as an impediment to U.S. competitiveness is the experience of Massachusetts and California. These states are commonly acknowledged as leading centers of innovation within the United States despite being heavily "burdened" with defense expenditures. Indeed, defense spending has frequently been seen as a vital contributor to these states' high technology leadership.

This article discusses the relationship between defense spending and the development of high technology industries, at both the national and the state levels. A particular focus of the article is whether the effects of defense spending on commercial innovation are different for a state than a nation.

Part I briefly reviews the arguments that defense spending impairs U.S. high tech competitiveness and finds little supporting evidence.[1] Part II looks at the relationship between the distribution of defense activity among states and the location of high technology industries. It finds that Massachusetts and California are unusual in the extent of their defense activity and their involvement in high technology industries with a predominantly commercial focus. High levels of defense spending in a state are not generally associated with unusually high levels of commercial high tech. Thus, the effect of defense spending on commercial innovation and high technology development appears neither as pernicious at the national level nor as advantageous at the state level as is sometimes portrayed.

I. Defense as a Hindrance to U.S. Competitiveness

The argument that defense spending impairs competitiveness seems to have been inspired by comparisons of defense spending and productivity growth in the industrialized countries. At least among the major non-communist industrial countries, higher ratios of defense spending to GNP have been associated with lower rates of productivity growth (Table 1). To infer from such a simple relationship among such a small number of very different countries that high defense spending actually causes low productivity growth is a considerable leap. However, in the context of the early 1980s, with defense spending increasing rapidly even as U.S. manufacturers were losing market share to foreign producers, especially the Japanese, the contrast between Japan's first place ranking in productivity growth and last place ranking in defense spending and the United States' first place ranking in defense spending and last place ranking in productivity growth took on added meaning.[2]

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One way in which defense spending is said to have weakened the U.S. competitive position is by discouraging commercial innovation and the development of new industry.[3] At first blush such a charge seems puzzling given the vast sums that the Department of Defense devotes to research and development and given the importance of defense spending to such high technology industries as aircraft, computers, and communications. The origins of the modern computer were the military's requirements in World War II; the military's communications needs in the 1950s and 1960s led to computer time-sharing, networks and computer graphics (DeGrasse 1984).

It is argued, however, that defense spending diverts research dollars away from activities that would have greater commercial payoffs than any spinoffs from defense. Professional and technical manpower is also diverted from commercial activities to defense. Other countries, without the same burden of defense spending, have been able to focus their research efforts and their professional manpower on developing new and superior products and manufacturing processes. The nature of defense procurement is also said to foster business practices inimical to innovation and successful competition in the commercial marketplace.

Drain on Technical Resources

The essence of the argument that defense spending diverts research dollars and professional and technical resources from private endeavors is that the supply of research monies and of personnel capable of conducting research is inelastic. Accordingly, research dollars spent on defense come out of nondefense research. Engineers and scientists working on defense projects would otherwise be applying these same skills to the problems of industry. They would not, in other words, be bankers or architects or salesmen. And even if defense demand attracts workers into these occupations, wages are bid up, curtailing private employment.

In considering the potential of defense spending to divert resources from commercial research and development, it should be recognized that more than 60 percent of defense outlays in 1985 were devoted to military personnel, operations and maintenance, military construction and family housing -- programs that do not absorb substantial scientific and engineering resources. Research and testing were responsible for about 12 percent of defense outlays in 1985; procurement, which also places a demand on such resources, accounted for 27 percent. Outlays for procurement and research and testing are more volatile than overall defense spending, however; these two programs accounted for over 50 percent of the increase in defense outlays from 1977 to 1985 (Henry and Oliver 1987, Table 2).

Demand for Engineers and Scientists - The National Research Council recently considered the relationship between defense spending and the nondefense engineering market and concluded that "defense outlays have not seriously affected the numbers of engineers available for nondefense work" (1986, p. iii). An Office of Technology Assessment memorandum (1985) on the scientific and engineering work force came to a similar conclusion. The reasoning behind these conclusions has three elements.

First and foremost, nondefense demand for engineers and scientists is considerably greater than defense. Only 20 percent of engineers with bachelor's degrees were working on defense-sponsored projects in 1984. For individual

engineering disciplines the defense share was higher, but for most categories of scientist and for computer specialists it was considerably lower.

Because nondefense demand is so much greater than defense, large changes in defense employment would have only moderate consequences for the supply of nondefense workers, even if defense and nondefense workers were perfect substitutes and the overall supply of engineers and scientists were fixed.

Secondly, nondefense and defense engineers and scientists are not perfect substitutes. Specialization is great and interdisciplinary mobility is low. Consequently, at least in the short term, fluctuations in defense demand will leave large segments of the science and engineering professions unaffected. The corollary to this argument is that competition between defense and commercial employers will be keen in those disciplines, such as electrical engineering, in which both sectors have substantial employment. However, the rewards of defense and commercial work are seen to be different and "the civilian sector is not a pushover in the contest for good engineers." (National Research Council 1986, p. 91)

Thirdly, despite low interdisciplinary mobility, the supply of engineers and scientists is not fixed. It responds to demographic factors, changing occupational preferences and changing employment opportunities. Improved job opportunities encourage college enrollments and, with a lag, lead to an increased number of professionals in the fields in question.[4] To a limited extent, supply can also be augmented in the shorter run by in-migration from other countries, recruitment from related fields such as physics and mathematics, upgrading of technicians and the retention in R&D capacities of individuals who would otherwise have moved into management.

Some have suggested that the problem is the quality of the engineers available for commercial work as much as it is the quantity, fearing that the inherent excitement of defense work siphons off the best minds: "Would the typical engineer rather work on designing a new missile with a laser guidance system or on designing a new toaster? To ask the question is to answer it." (Thurow 1981, p. 6) However, a National Research Council survey of university placement officers found that commercial opportunities are prized because they offer greater potential for advancement and more varied challenges. In a similar vein, the Office of Technology Assessment surveyed the market for electrical engineers in the Boston area, where both commercial and defense activities are well represented, and concluded that "The military engineer is viewed as more risk averse, less creative and less likely to be interested in advancement. In contrast the civilian engineer is viewed as more people oriented, more talented, better able to bring out products and more selective." (1985, p. 105)

The key point, however, is that the engineering and science labor market in the United States is predominantly a commercial market. If the number of engineers and scientists available for commercial work is too small or lacking in quality, competition from defense demand is not the primary reason.

Defense and R&D Spending - While research is a relatively small fraction of total defense outlays, defense research is a relatively large fraction of total U.S. research and development expenditures (Chart 1). Federal defense-related outlays accounted for 30 percent of total U.S. R&D expenditures in 1985, federal space research another 6 percent. Although the defense share in

Table 1

Defense Spending Relative to GNP and Annual Rates of Productivity Growth, Twelve Countries, 1960–86

Percent

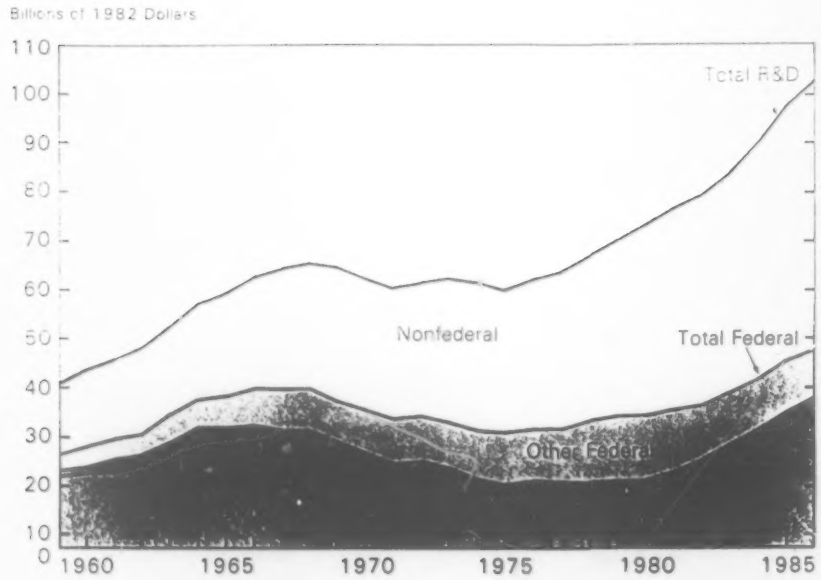
	Defense Spending as a Share of GNP[a]	GDP per Employed Person	Manufacturing Output per Hour
United States	6.4	1.2	2.8
United Kingdom	5.2	2.2	3.6
France	4.3	3.6	5.2
West Germany	3.6	3.1	4.6
Netherlands	3.4	2.3	5.9
Sweden	3.4	2.3	4.6
Norway	3.3	2.9	3.2
Belgium	3.1	3.1	6.3
Italy	2.7	3.7	5.7
Denmark	2.3	2.2	4.6
Canada	2.3	1.9	3.3
Japan	9	5.5	7.9
Correlation between Defense/GNP and Productivity Growth			
Correlation Coefficient		−.63	−.63
t-statistic		(−2.6)	(−2.5)

[a] Average of defense shares in 1965, 1970, 1975, 1980, and 1984.

Source: Defense as a share of GNP—Central Intelligence Agency, *Handbook of Economic Statistics 1987*; productivity figures—U.S. Bureau of Labor Statistics, Office of Productivity and Technology, "Comparative Real Domestic Product, Real GDP Per Capita, and Real GDP per Employed Person, Thirteen Countries, 1950–1986," August 1987 and "Output per Hour, Hourly Compensation and Unit Labor Costs in Manufacturing, Twelve Countries 1950–86," December 1987.

Chart 1

U.S. Research and Development Outlays



Source: Statistics

1985 was substantially above that in the second half of the 1970s, it was still below that in the 1960s. Defense and space research was responsible for more than half of all R&D expenditures in the early 1960s, compared to somewhat over one-third today.

The expansion in defense R&D in the 1980s was accompanied by a cutback in federal R&D outlays for nondefense purposes. Thus, one might be tempted to argue that the increase in defense occurred at the expense of federal nondefense activity. The assumption that research dollars cut from defense will be available to fund other federal research projects underlies many criticisms of defense spending. While a budgetary trade-off between defense and nondefense R&D seems to exist, the pool of federal research monies is not fixed. A dollar of spending for defense does not reduce nondefense research by a dollar, and a dollar less for defense rarely means a dollar more for nondefense. The increase in defense R&D in the 1980s was far greater than the cutbacks in other federal research; and when defense R&D was reduced in the early 1970s, federal nondefense R&D did not grow by the amount of the defense cuts. Moreover, in the late 1950s and early 1960s the expansion in defense and space research was accompanied by rapid growth in federal nondefense R&D, indicating that increased outlays for defense R&D need not preclude increases in nondefense activity.

Most federally funded R&D is actually performed by business firms, universities and other nonprofit institutions rather than by the federal government itself. Most nonfederal R&D is both funded and performed by industry. Nonfederal R&D expenditures have risen fairly steadily in real terms since the mid-1950s and now represent more than half of all R&D spending. This steady rise in industry-supported R&D seems inconsistent with the view that federal defense research has an adverse effect on private activity. Indeed, if there is a pattern, it shows that nonfederal research expenditures have grown most rapidly when defense and space research was expanding. Thus, both the surge in defense and space research in the 1950s and early 1960s and the expansion in defense in the 1980s were accompanied by strong growth in nonfederal R&D. During the 1970s, when defense and space research was cut back, nonfederal R&D grew more slowly. (Some industry-financed R&D could be for defense purposes. Data are not available that would permit one to rule out such a possibility. However, generally when a business firm engages in defense research, the federal government pays.)

Thus, an examination of R&D expenditures in the United States over time shows no evidence that defense work discourages industry R&D, and while there may be a trade-off between expenditures and federal nondefense R&D, it is certainly not dollar-for-dollar. The trade-off between defense and nondefense research would be even less than Chart 1 suggests to the extent that defense research and associated procurement serve nondefense purposes.

Defense Spending for Commercial Purposes

Most critics of defense spending acknowledge that it has produced significant commercial spin-offs. Some of these spin-offs were largely fortuitous, in the sense that no one foresaw such an outcome. To some extent at least, the computer would seem to fall into this category. It was originally developed to speed up ballistics calculations, and while the commercial possibilities were recognized fairly quickly, in the very early days customers were expected to be limited to the military, defense contractors and a few other large government organizations.

Sometimes, however, the potential for commercial benefits is recognized from the start and is an important motivation for the defense expenditures. Recent proposals to strengthen U.S. chip-making capabilities seem to be a case in point. Much of the impetus for research in this area comes from largely commercial firms facing competition from overseas rivals. They seek support from the Department of Defense because it is an important customer and also because they see it as having the dollars to fund a major research effort. The Department of Defense is supportive because it wants to ensure a reliable supply of specialized chips for military purposes and fears dependence on foreign chip producers. Thus, these proposals have both a commercial motivation and a national security motivation.[5]

Will both commercial and military goals be well served by such arrangements? If the Department of Defense is a major supplier of research funds, it will have a powerful influence on the research program and the nature of the products and processes developed. Critics of defense spending contend that military needs are not very similar to commercial requirements. The military is said to be less concerned about cost than are commercial customers.

Performance is foremost, but the performance is so specialized and extreme that critics see little potential for commercial applications. In awarding contracts, the military is also said to rely on established firms with which it has dealt in the past, and to ignore smaller, potentially more innovative upstarts. The military is secretive, and for national security reasons may be reluctant to see research findings disseminated widely, thereby reducing the prospects for spin-offs. Of course, commercial firms can also be very secretive about their activities for competitive reasons.

The possibility of distortions arising from defense involvement is all the more disturbing if U.S. defense expenditures inspire or compel other countries to undertake similar efforts with a more commercial focus. It has been suggested that governments in other countries see U.S. defense research and procurement as a form of industrial policy generating commercial spin-offs. They fear being left at a technological disadvantage and, to protect themselves, they have responded with their own research programs. These are more commercially focused than the U.S. effort and, from a commercial standpoint, more effective.

It stands to reason that research dollars spent to serve both commercial and military purposes will not have the same commercial impact as dollars spent in the same area solely for commercial purposes. An intriguing question, however, is whether the dollars would be spent at all without the link to defense.

While some commercial producers may look to the defense sector to bankroll research they would otherwise undertake on their own, one implication of the various criticisms of defense involvement is that most commercial firms would normally prefer to avoid relying on the Department of Defense. They turn to it only when the commercial payoffs are uncertain and the risks are high. Past R&D patterns provide little indication that defense research substitutes for industry effort.

As for federal R&D expenditures, national security seems the most powerful motivator. The surge in federal R&D in the late 1950s and early 1960s was a response to the challenge implied by the launching of Sputnik as well as to

the needs of the Vietnam War. The increase in R&D under the Reagan administration, which restored expenditures to the fraction of GNP they were in the 1960s, was entirely defense-driven. Without a perceived threat to national security, a strong consensus for major research expenditures does not seem to develop in the United States. Indeed, even those who criticize defense spending on competitiveness grounds frequently appeal to the public's concern for national security, arguing that the negative economic effects they attribute to defense spending actually jeopardize security.

II. Defense and High Tech Development at the State Level

While defense spending has been accused of undermining U.S. competitiveness, it has also been seen as an important impetus to growth for various states and regions within the United States. Most commonly, defense spending's influence on states is seen in terms of the dollars flowing into the states in the form of procurement or payroll and the resulting multiplier effects on more locally oriented activities. However, in some states -- Massachusetts and California in particular -- defense procurement and research activities are credited with laying the foundation for high technology industries with a strong commercial, as well as military, orientation.

The effect of defense spending on innovation and the development of new industries might be more favorable for a state than for the country as a whole for several reasons. The argument that defense research comes at the expense of nondefense R&D, whatever its merits for the nation, seems much more tenuous at the state level. Publicly funded research is overwhelmingly federally funded research. Consequently, the public monies available for research in a given state are not limited by the financial resources or willingness to pay of the state but of the nation.[6]

Of course, the capacity to carry out research and innovate involves more than federal dollars. Research absorbs real resources, in particular professional and technical manpower. Again, however, the argument that defense activity diverts scarce professional manpower away from nondefense R&D seems much weaker applied to a state than to the nation. The supply of professional and technical manpower is undoubtedly more elastic at the state level, simply because workers can be recruited from other states. Even for the nation, immigration is a nontrivial source of professional and technical workers, and professional mobility is greater within the United States than from other countries to the United States. Indeed, to the extent that professional and technical workers are attracted to areas offering many employment opportunities, the presence of defense contractors may enhance the recruiting abilities of nondefense employers.

All of this is simply to say that trade-offs between defense and nondefense research and innovation at the national level need not imply trade-offs for individual states. Moreover, since all but the most vociferous critics of defense spending acknowledge the potential for commercial spin-offs, states in which defense research and procurement activity takes place may have an advantage in securing the benefits of these commercial spin-offs and, thus, a head-start in nondefense innovation. Several authors have explained the development of high technology industries in Massachusetts in these terms.[7]

Massachusetts is a leading center for defense research and procurement activity. For many years, its share of prime defense contract awards has been

double its share of U.S. employment. Massachusetts is also widely recognized as a center for high technology industries, especially computers. Not only does the development of the computer owe much to the military's requirements in World War II, but the emergence of computers as a major Massachusetts industry can be traced, in large part, to defense research at the Massachusetts Institute of Technology in the late 1940s and early 1950s (Warsh 1986).

Despite its military origins, the computer industry today is primarily commercial in focus. Defense spending accounts for only about 5 percent of computer output, about the same as the defense share of output for refining or real estate (Henry and Oliver 1987). The situation is similar for the semiconductor industry, which is given much of the credit for the development of California's Silicon Valley. Once heavily dependent upon defense demand, it too has evolved into a predominantly civilian industry with only 5 percent of its output attributed to defense spending.

Are these exceptions or the rules? Is the Massachusetts and California experience unique or do defense research and procurement generally foster high technology development at the state level? The following sections examine the relationship between the geographic pattern of defense purchases and the location of high technology industries.

Defining High Technology and Defense-Related Industries

The term high technology is used to denote technologically sophisticated industries, usually manufacturing, that employ relatively large numbers of professional and technical workers and engage in significant research and development efforts for the purpose of developing new or substantially improved products and processes. Industries possess these characteristics to varying degrees. As a consequence, different definitions of high technology industries have been adopted by different researchers. The definition used in this article is one of three developed by the U.S. Bureau of Labor Statistics. It "includes manufacturing industries with a proportion of technology-oriented workers equal to or greater than the average for all manufacturing industries and a ratio of R&D expenditures to sales close to or above the average for all industries" (Riche, Hecker and Burgan 1983, Table 1). (Two nonmanufacturing industries are also considered high tech under this BLS definition, but they have been excluded from this article's list of high tech industries because of the customary identification of high tech with manufacturing.) These high tech manufacturing industries and their U.S. employment in 1985 are shown in Table 2.[8]

The most readily available measure of the geographic distribution of defense research and procurement activity is the value of prime defense contract awards received by businesses and other institutions in each state. However, prime contracts have a drawback as an indicator of defense orientation. Because subcontracting can be substantial, prime contracts may not show where the work is really performed. Studies of the effect of subcontracting on the distribution of defense purchases have come to different conclusions. Some have found that "Rather than decreasing the degree of spatial concentration, subcontracting by defense contractors maintains or increases it slightly" (Malecki 1984, p. 42). However, analyses by the Defense Economic Impact Modelling System, using input-output techniques, suggest that the indirect spending effects are more geographically diffuse than the distribution of prime contracts.[9]

Largely because of the subcontract issue, some researchers have chosen to approximate states' defense orientation according to the fraction of employment in defense-related industries, that is, industries for which defense spending accounts for a large share of output (O hUallachain 1987). Table 3 shows the industries that analysts at the Department of Commerce and the Bureau of Labor Statistics have identified as most dependent upon defense spending, taking into account both direct and indirect purchases. Although these are the most defense-dependent industries, in only a few does defense account for the bulk of the industries' business. In some, the space program and military sales abroad, which are not counted as defense spending, represent significant fractions of demand. Nevertheless, most "defense-dependent" industries derive the greater portion of their business from civilian markets rather than defense.

Table 2
High Technology Industries and 1985 U.S. Employment

SIC	Industry	U.S. Employment 1985	Share of Total Private Employment (percent)
281	Industrial Inorganic Chemicals	142,425	.18
282	Plastics Materials & Synthetics	172,792	.21
283	Drugs	206,307	.26
284	Soap, Cleaners, & Toilet Goods	144,989	.18
285	Paints & Allied Products	63,803	.08
286	Industrial Organic Chemicals	159,564	.20
287	Agricultural Chemicals	59,119	.07
289	Misc. Chemical Products	95,191	.12
291	Petroleum Refining	140,985	.18
348	Ordnance & Accessories, n.e.c.	78,099	.10
351	Engines & Turbines	105,870	.13
355	Special Industry Machinery	170,482	.21
357	Office & Computing Machines	516,749	.64
361	Electric Distributing Equipment	114,794	.14
362	Electrical Industrial Apparatus	195,826	.24
365	Radio & TV Receiving Equip.	83,939	.10
366	Communication Equipment	652,773	.81
367	Electronic Components & Access	664,768	.83
369	Misc. Electrical Equip & Supplies	155,328	.19
372	Aircraft & Parts	636,518	.79
376	Guided Missiles, Space Vehicles, Parts	173,810	.22
381	Engineering & Scientific Instruments	80,305	.10
382	Measuring & Controlling Devices	253,695	.32
383	Optical Instruments & Lenses	34,229	.04
384	Medical Instruments & Supplies	173,755	.22
386	Photographic Equip. & Supplies	122,506	.15
	Total High Tech	5,398,621	6.71

Source: *Employment and Wages, Annual Averages 1985.*

Neither computers nor semiconductors is on the list of defense-dependent industries. Although both rank in the top 20 industries in terms of absolute value of defense sales, so large are their commercial markets that defense is responsible for only 5 percent of total output. In contrast, for a number of industries that are not usually considered tied to defense, a combination of rising defense demand and weak commercial sales caused the defense fraction to increase dramatically in the 1980s. Perhaps the most striking example is metal cutting machine tools. From 8 percent in 1980 the fraction of output attributable to defense rose to 34 percent in 1985. The reason for the increased defense share was a very large increase in defense output (65 percent) and very large decreases in nondefense (70 percent) and total output (60 percent). One implication of such fluctuations is that defense dependence for many industries is more a function of the economic and political environment of the time than the inherent characteristics of the industry.

Table 3
Defense-Dependent Industries

SIC	Industry	Defense Share of Output (percent) 1977	1980	1985	Number Employed 1985
103–105[a]	Nonferrous Metal Ores Mining, except Copper	8	11	26	13,487
1021	Copper Ores	5	6	11	12,644
2892	Explosives	36	41	65	17,674
3131	Boot and Shoe Cut Stock and Findings	11	14	12	7,133
3299	Nonmetallic Mineral Products, n.e.c.	7	9	17	7,148
3312	Blast Furnaces and Steel Mills	5	6	12	238,501
3313	Electrometallurgical Products	6	6	15	9,139
3331	Primary Copper	7	10	18	5,339
3332	Primary Lead	6	7	17	2,300
3333	Primary Zinc	9	11	22	1,870
3334	Primary Aluminum	7	9	22	24,650
3351	Copper Rolling and Drawing	5	7	17	23,927
3356	Nonferrous Rolling and Drawing, n.e.c.	8	13	18	16,249
3369	Nonferrous Castings, n.e.c.	9	10	17	18,866
3451	Screw Machine Products	6	7	13	46,0
3462	Iron and Steel Forgings	8	10	19	35,182
3463	Nonferrous Forgings	21	12	25	6,635
3471	Plating and Polishing	11	11	13	74,533
3482	Small Arms Ammunition	37	30	39	12,058
3483	Ammunition, except Small Arms, n.e.c.	65	88	88	42,228
3484	Small Arms	20	26	48	14,520
3489	Ordnance and Accessories	61	79	86	9,293
3511	Turbines and Turbine Generator Sets	5	7	23	32,312
3535	Conveyors and Conveying Equipment	3	6	12	30,550
3536	Hoists, Cranes, and Monorails	3	4	13	13,367
3541	Machine Tools, Metal Cutting Types	3	8	34	54,474
3542	Machine Tools, Metal Forming Types	2	6	15	18,944
3562	Ball and Roller Bearings	7	7	15	46,664
3569	General Industrial Machinery, n.e.c.	3	8	15	53,497
3621	Motor and Generators	5	10	24	96,673
3622	Industrial Controls	5	6	11	62,224
3624	Carbon and Graphite Products	5	7	15	10,779
3662	Radio and TV Communication Equipment	35	42	50	509,966
3671–3673	Electron Tubes	12	14	26	41,727
3675–3679	Electronic Components except Tubes, Semiconductors	15	16	20	343,805
3713	Truck and Bus Bodies	2	8	22	36,711
3715	Truck Trailers	5	10	29	29,208
3721	Aircraft	43	37	66	327,165
3724 & 3764	Aircraft and Missile Engines and Parts	47	44	78	165,301
3728 & 3769	Aircraft and Missile Equipment, n.e.c.	38	31	41	183,074
3731	Ship Building and Repairing	45	61	93	140,025
3761	Guided Missiles and Space Vehicles	67	69	84	134,787
3795	Tanks and Tank Components	40	68	69	20,256
3811	Engineering and Scientific Instruments	19	23	23	80,305
3832	Optical Instruments and Lenses	14	13	24	34,229

Note: Industries listed are industries in which defense accounts for more than 10 percent of output. [a] The defense shares of output for industries 103–105 include parts of 108 and 109.

Source: Henry and Oliver 1985. *Employment from Employment Wages, Annual Averages, 1985.*

For the purpose of examining the association between state defense orientation and the location of high technology industries, which is presumed to be a long-term relationship, the industries classified as "defense-related" should be those for which defense spending accounts for a substantial fraction of output under normal circumstances. Accordingly, defense-related industries were defined as those for which defense accounted for more than 15 percent of output in 1977 and 1980, before the Reagan buildup. Optical instruments and electron tubes were also included because the defense share was close to the cutoff in both earlier years, as well as relatively high in 1985. These defense-related industries are highlighted in Table 3. (A case can be made for adding one additional industry to the list of defense-related industries. Industrial inorganic chemicals, not elsewhere classified (SIC 2819), includes establishments engaged in the manufacture of nuclear materials. However, the Department of Energy rather than the Department of Defense is responsible for the production of nuclear weapons. Consequently, industry 2819 does not appear to derive a large fraction of output from defense spending according to the criteria used to develop the list of industries in Table 3, and thus, it is not considered a defense-related industry in this article. The conclusions of the article are not sensitive to whether industry 2819 is considered defense-related. Less than 10 percent of U.S. employment in chemicals is in this component.)

Comparing the defense-related industries highlighted in Table 3 with the list of high tech industries in Table 2 reveals that most defense-related industries are also high tech industries.[10] Indeed, the exceptions, of which shipbuilding is the most important, accounted for only 10 percent of U.S. employment in defense-related industries. While almost all defense-related industries are high tech, the reverse is not true. Not all high tech industries are defense-related. Measuring and controlling instruments and medical instruments are not defense-related. Computers and semiconductors are not defense-related today, even if they were at one time. However, a sizable fraction of high tech employment, over 30 percent in 1985, is in industries also defined as defense-related. Aircraft and parts and radio and TV communication equipment are the most important of these defense-related high tech industries.

Defense-Oriented States

Table 4 lists the 10 most defense-oriented states as indicated by (1) employment in defense-related industries as a fraction of total private employment in 1985 and (2) share of prime defense contracts relative to share of U.S. employment for the years 1984-86.[11] Both measures show a strong defense orientation in Connecticut and Massachusetts; along the Pacific coast in California and Washington, although not Oregon; in Missouri and Kansas; in Maryland and Virginia; and, to a somewhat lesser extent, in Arizona and Utah. Defense orientation is lowest in some of the rural Mountain and Plains states, as well as in a few southern states. The most notable difference between the two measures is their characterization of New England. Based on the fraction of employment in defense-related industries the entire region is strongly defense-oriented, whereas contract awards show defense activity to be concentrated in Connecticut and Massachusetts.

Although overall defense spending rises and falls rather sharply over time, the relative defense orientation of individual states is fairly stable. Thus, eight of the 10 most defense-oriented states according to the fraction of employment in defense-related industries in 1985 were also in the top 10 in 1979.[12] Similarly, for contract awards, nine of the 10 most defense-oriented states according to 1984-86 contracts awards relative to employment ranked at the top in the 1978-80 period.[13]

Defense-oriented states tend to be high tech states. Of the 10 states with the highest shares of employment in defense-related industries all but Maine had larger fractions of employment in high technology industries than the country as a whole. The reason that defense-oriented states are also high tech states is the overlap between industries defined as defense-related and also as high technology industries. States such as Kansas and Washington, with very large aircraft industries, necessarily have substantial fractions of both defense-related and high tech employment. A strong defense orientation is not generally associated, however, with a large fraction of employment in high technology industries that are not defense-related.

These patterns are shown by the simple correlations in Table 5. These relate the fraction of employment in high tech industries in 1985 to state defense orientation in 1979 measured both as the fraction of private employment in defense-related industries and as prime contract awards relative to employment. High tech employment in 1985 is compared with defense orientation in 1979 on the grounds that the recent defense buildup could have caused states' defense activity to deviate from normal. Also, any causal link running from defense activity to high tech would operate with a lag. When defense orientation is compared with the fraction of employment in all high technology industries, the correlations are positive and statistically significant; but when defense orientation is compared with employment in high technology industries excluding those that are defense-related, the relationships are not statistically significant.[14]

Chart 2 plots the share of employment in high technology industries, excluding those considered defense-related, against the fraction of employment in defense-related industries. Some states, including Massachusetts and California, have relatively large fractions of employment in both defense-related industries and these more commercially oriented high technology industries. A number of small states with little manufacturing activity lack both. However, Delaware, with an unusually large fraction of employment in commercial high tech, has almost no defense activity while Kansas and Washington, with very large defense-related employment shares, have little commercial high tech.

Thus, the geographic pattern of defense activity and high technology employment provides little indication that defense activity has been a general stimulus to the growth of more commercially oriented high technology industries at the state level. This statement must be qualified by recognizing that even the more defense-dependent industries have substantial commercial business. Nevertheless, the Massachusetts and California experience does not seem to be representative of a general relationship between defense activity and high tech development. Reasons why this may be so are discussed below.

Composition of Defense-Related and High Tech Industries

Defense-oriented states that also have substantial commercial high tech employment have a more varied mix of defense-related industries than defense-oriented states with little commercial high tech. In most of the latter, the strong defense orientation is due to one very large industry and, in some cases, one very large employer. In Washington it is the aircraft industry, and Boeing Co. in particular, that is responsible for the state's large fraction of defense-related employment. In Maine, it is shipbuilding and the Bath Iron Works; in Kansas it is aircraft again (see Table 6).

Table 4

Ten Most Defense-Oriented States in 1985, according to:

Employment in Defense-Related Industries / Private Employment		Share of Prime Contracts[a] / Share of U.S. Employment	
Connecticut		Connecticut	
Washington		Missouri	(11)
New Hampshire	(18)	Massachusetts	
California		California	
Kansas		Maryland	(14)
Massachusetts		Alaska	(50)
Utah	(16)	Virginia	(13)
Vermont	(35)	Kansas	
Maine	(13)	Mississippi	(15)
Arizona	(11)	Washington	

[a]Average of 1984, 1985, and 1986.

Note: Figures in parentheses are rankings in the other listing.
Source: See appendix table 2.

Table 5

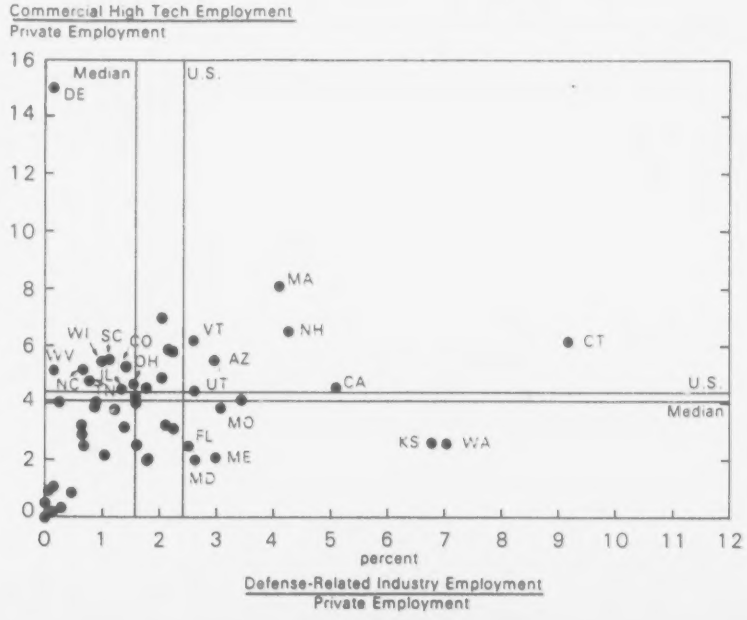
Correlations between Defense Orientation in 1979 and High Tech Employment in 1985

	Correlation Coefficients			
	Employment in Defense-Related Industries / Private Employment		Prime Contract Share / Employment Share	
	All	Large States	All	Large States
High Tech Employment / Private Employment	.60 (5.1)	.71 (5.6)	.45 (3.5)	.68 (5.2)
Non-Defense High Tech / Private Employment	.15 (1.0)	.08 (.5)	.16 (1.1)	.25 (1.4)

No. of observations = 50 for all states; 34 for large states (private employment exceeding 500,000 in 1985).
Figures in parentheses are t-statistics.

Chart 2

Relationship between Commercial High Tech Employment in 1985 and Employment in Defense-Related Industries in 1979



Source: U.S. Bureau of Labor Statistics, complete tape of ES-202 data.

Table 6

Comparison of 1979 Defense-Related and 1985 Commercial High Tech Employment in Selected States

Percent

		Industry Share of Total Defense-Related Employment 1979						
	Defense-Related Share of Private Employment	Ordnance 348	Radio and TV Communications Equipment 3662	Electronic Components 367 except 3674	Aircraft 372	Shipbuilding 373	Missiles 376	Engineering and Optical Instruments 381 + 383
United States	2.4	3.5	20.4	18.3	34.7	9.9	5.4	6.0
High Defense-Related High Commercial High Tech[a]								
Connecticut	9.2	5.6	5.6	8.0	57.6	15.8	0	6.4
California	5.1	.4	28.3	15.7	35.6	3.8	10.4	4.4
New Hampshire	4.3	11.0	30.9	43.4	0	0	0	14.7
Massachusetts	4.1	5.6	23.1	25.9	11.5	7.1	13.6	10.8
Arizona	3.0	0	9.3	8.0	45.1	0	17.7	18.6
Utah	2.6	.9	4.7	32.1	57.5	0	1.9	1.9
Vermont	2.6	0	0	34.1	48.8	0	0	2.4
High Defense-Related Low Commercial High Tech[b]								
Washington	7.0	.1	3.5	.3	81.0	10.7	3.7	.4
Kansas	6.8	2.2	6.4	3.0	86.0	0	0	1.6
Missouri	3.1	4.4	3.2	21.8	64.2	3.2	1.2	1.2
Maine	3.0	7.1	7.1	20.2	2.0	57.6	0	4.0
Maryland	2.6	.3	56.8	3.6	14.2	18.1	2.1	4.5
Florida	2.5	1.0	34.4	11.4	24.5	12.0	14.5	1.6

[a] States with shares of defense-related and commercial high tech employment exceeding those in the United States and the median state.

[b] States with shares of defense-related employment greater than and shares of commercial high tech less than those in the United States and the median state.

[c] States with shares of defense-related employment less than and shares of commercial high tech greater than those in the United States and the median state.

Source: U.S. Bureau of Labor Statistics, computer tape of ES-202 data.

	Commercial High Tech Share of Private Employment	Industry Share of Total Commercial High Tech Employment 1985							
		Chemicals 28 except 2892	Refining 291	Computers 357	Various Machinery 351+355	Telephone Apparatus 3661	Semi-conductors 3674	Various Electrical 361+362+365+369	Various Instruments 382+384+386
United States	4.3	29.5	4.0	14.8	7.9	4.1	8.0	15.8	15.8
High Defense-Related High Commercial High Tech[a]									
Massachusetts	8.0	8.8	0	28.2	9.5	6.1	17.3	9.4	20.7
New Hampshire	6.5	3.9	0	49.0	13.1	0	5.4	8.5	20.1
Vermont	6.2	7.1	0	3.5	3.5	0	77.9	14.2	14.2
Connecticut	6.1	26.1	0	10.2	11.7	3.6	2.2	23.8	22.5
Arizona	5.5	6.2	.2	27.8	1.5	.9	51.6	3.6	8.6
California	4.5	14.5	6.2	25.4	4.4	2.2	15.4	11.3	20.7
Utah	4.4	12.3	3.9	43.1	2.9	1.5	14.7	3.9	17.2
Low Defense-Related High Commercial High Tech[c]									
Delaware	14.9	87.2	2.4	1.1	.5	0	0	6.0	2.7
South Carolina	5.5	57.4	0	3.2	17.0	0	1.1	11.8	9.0
Wisconsin	5.3	11.3	.2	3.3	36.6	.5	.2	39.9	7.9
Colorado	5.3	12.5	1.0	25.0	2.4	10.8	6.7	7.8	33.0
North Carolina	5.1	33.2	0	17.9	9.6	12.4	.4	18.4	7.9
West Virginia	5.1	86.4	1.8	0	1.3	0	.4	5.7	3.9
Tennessee	4.7	55.5	0	3.2	3.8	2.8	.1	24.4	10.1
Ohio	4.6	37.3	3.5	8.1	12.7	4.5	1.0	21.2	11.8
Illinois	4.4	33.5	3.8	3.0	10.8	10.2	.5	20.6	17.6

In contrast, Massachusetts and California are active in a number of defense-related industries: communications equipment, electronics and missiles all account for relatively large shares of employment; aircraft is also an important industry in California and a significant employer in Massachusetts. Most of the other defense-oriented states that rank high in commercial high tech employment are also active in several defense-related industries, although they tend to be more specialized in their defense orientation than Massachusetts and California.

The most important commercial high tech industries in these states are computers, semiconductors and instruments (measuring and controlling, medical and photographic). The chemicals industry accounts for a smaller fraction of employment in these states than it does nationwide. In contrast, chemicals tends to be quite important and computers, semiconductors and instruments relatively unimportant in the states with substantial commercial high tech and little defense activity.[15] Delaware is the extreme example of a high tech state with virtually no defense-related employment. In Delaware 15 percent of private employment is in commercial high tech; chemicals accounts for almost all of this.

These patterns suggest several conclusions. First, substantial employment in defense-related industries is not regularly associated with employment in high technology industries that are not themselves defense-related. In particular, the chemicals industry is not generally found in proximity with defense-related industries. Second, a link may exist between defense activity and the computer, semiconductor and commercially oriented instruments industries. However, substantial defense-related employment does not guarantee the presence of these industries, especially if the defense-related employment is concentrated in one large industry. Third, Massachusetts and California are not typical defense-oriented states or even typical high tech states, despite being regarded as the models for both.

That chemicals is not regularly associated with defense-related industries is not especially startling. Although chemicals and defense-related industries employ large numbers of professional and technical workers, the body of knowledge required in chemicals in quite different. Consequently, the opportunities for individuals or ideas to move between the chemicals industry and, for example, communications equipment are limited. Moreover, the location of the chemicals industry is influenced by such factors as resource availability and energy costs. The absence of an association between chemicals and defense-related industries is nevertheless significant as a reminder that not all high technology industries are the same. For many people the term "high technology" calls to mind the computer industry, and because of the computer industry's military origins, as well as the fact that most defense-related industries are also high tech, people tend to view all high tech as tied to defense spending. This is not the case. Even computers have grown beyond defense dependence. More generally, not all high technology industries have had -- or will have in the future -- the same history of development or pattern of location as computers.

High employment shares in computers, semiconductors and various types of instrumentation are frequently associated with high fractions of defense-related employment. However, the presence of a single large defense-related industry does not seem to favor the development of these industries. For shipbuilding, which is not a high tech industry, the absence of such an association is perhaps not surprising. The aircraft and parts industry is another matter.

Not only does the aircraft industry employ large numbers of engineers and technical workers, but, in addition, the product incorporates highly sophisticated navigation and communications systems, suggesting considerable interdependence between aircraft and other high tech industries. However, the presence of a large aircraft industry in Washington and Kansas has neither attracted other high tech industries nor generated spin-offs. This was also the conclusion of a study of the aerospace industry in Bristol, England; although some small-scale subcontracting took place locally, "the spawning of new companies by aerospace has been minimal." (Boddy and Lovering 1985, p. 224)

Although some of the defense-oriented states that are active in commercial high tech have large aircraft industries, other defense-related industries are also important. Perhaps the links from these industries -- missiles, communications equipment and electronics -- to computers and semiconductors are stronger than those between aircraft and commercial high tech. However, another interpretation is that a diverse high tech base is more favorable to further high tech development than the presence of one dominant technologically advanced industry.

Where one industry is dominant, opportunities for the cross-fertilization of ideas are limited. R&D advances are likely to be evaluated solely in terms of their applications in the dominant industry, and if not relevant set aside and ignored. Decisions not to pursue an idea may be explicit, but they may also come about simply because researchers are not exposed to different market needs and ways of doing things and, thus, fail to see other possibilities. Additionally, when a dominant industry is characterized by high wages and very large employers, as is the case for aircraft, other industries may have difficulty competing for workers. The problem is not so much that engineers and technical personnel are diverted from other activities, as these can be recruited nationally. Rather, large, high-wage employers may set the standard for what constitutes a "good job" in their area, forcing other local employers to match their wages and employment practices or risk morale problems and turnover. It has also been suggested that life in a big company can be so comfortable for professional and managerial workers that it discourages entrepreneurial endeavor. These concerns have been raised in connection with the auto industry's effect on industrial development in the midwestern states, but they also seem applicable to large, high-wage defense contractors.[16]

In a more diverse high tech environment, people working on defense-related projects are more likely to be exposed to alternative career paths, to technologies that might be complementary to ones on which they are working, to research questions they would not otherwise have considered, and to the opportunities in commercial markets. An interesting illustration of the potential for interaction is columnist David Warsh's recounting of how a Massachusetts physicist working on miniaturized devices for spies came to participate in developing an ultrasound-guided laser for removing plaque from arterial walls (Warsh 1987). The physicist attended a technology day sponsored by the Lahey Clinic, a Boston area medical center. The problem of seeing inside the artery was presented and the physicist recognized that his expertise offered a solution. Arthur D. Little, a prominent engineering consulting firm in the area, became involved; funds were raised and work begun on a prototype.

It is, of course, possible that some states have disproportionate shares of both defense-related and commercial high tech industries not so much because defense spending has led to commercial spin-offs but because their locational

attributes -- for example, fine research institutions, generally high levels of education, and quality of life -- make them attractive locations for a variety of high technology industries, both defense-related and commercial. These are not mutually exclusive alternatives. An area might attract defense expenditures for much the same reasons that it is a center for commercial high technology industry, but the defense expenditures might then generate spin-offs reinforcing its commercial position.

It is important to recognize, however, that the number of states in which high levels of defense activity are associated with substantial commercial high technology employment is small. Defense spending may have contributed to their commercial high tech success, but it is difficult to generalize from the experience of so few states.

Role of Defense Research

A further reason for thinking that the Massachusetts experience in particular is atypical is the unusually high fraction of its defense contracts awarded for research, development, test and evaluation. While RDT&E accounts for less than 15 percent of all U.S. prime contract awards, in Massachusetts the RDT&E share is roughly 25 percent. Other states with disproportionately large RDT&E awards are California, Maryland, Washington, and, recently, Colorado and Utah.[17] Not only does Massachusetts receive a large share of RDT&E awards, but the state also differs from both the rest of the country and most other recipients of large RDT&E awards, including California, in the fraction of contracts awarded to universities and other nonprofit institutions. In the country as a whole, approximately 90 percent of RDT&E awards go to business firms. However, in Massachusetts the business share in the 1980s has been only 60 percent. M.I.T. and the nonprofit MITRE Corporation and Charles Stark Draper Lab account for almost all of the remainder.

Casual reasoning suggests that RDT&E awards would be more likely to result in technological advances than procurement awards generally. A significant fraction of all contract awards are not for sophisticated hardware but for more mundane purchases such as petroleum, food products, textiles and clothing, and construction. Moreover, even for advanced products, much of the value of the contract covers the cost of purchased materials and the assembly of the final product; design and engineering work is frequently paid for under a separate RDT&E contract.

Additionally, RDT&E awards to a university may have a greater chance of producing commercial spin-offs than awards to business firms. The university should provide an environment more favorable to cross-fertilization, in that faculty and students are exposed to colleagues from a variety of disciplines, drawing upon different bodies of knowledge to address different questions. The use of student researchers means that a stream of people with fresh ideas, some of whom will eventually work in commercial fields, are exposed to defense research efforts. Also, such university goals as enhancing a reputation for high quality research and providing graduates with attractive career opportunities can be furthered by the discovery of applications beyond the initial scope of a particular government contract. Even if the corporate defense contractor is alert to the possibility of commercial applications, it is unlikely to have much interest in applications that it cannot exploit itself.

Defense research, even at universities, is clearly not a sufficient condition for local commercial spin-offs. Maryland receives a disproportionate share of RDT&E contracts and The Johns Hopkins University accounts for much of this, yet Maryland has relatively little commercial high tech. Nevertheless, the research-intensive nature of Massachusetts' defense contracts may be part of the explanation for the association between defense activity and commercial high tech in the state. At a minimum, it is another reason why Massachusetts cannot be considered a typical defense state and why one cannot assume that links between defense and commercial high tech in Massachusetts will be replicated elsewhere.

III. Summary and Conclusions

The focus of this article has been the apparent contradiction between concerns that defense spending is undermining U.S. competitiveness by diverting skilled manpower and research monies from commercial to military ends, on the one hand, and the frequently cited links between defense and the development of high technology industries in Massachusetts and California, on the other. In an attempt to resolve this contradiction, Part I considered the relationship between defense spending and research activity at the national level, while Part II looked at the pattern of defense activity and high tech location by state.

While comparisons among countries suggest an association between high defense spending and low productivity growth, an examination of U.S. experience over time provides little support for the view that defense spending is the cause of poor U.S. performance. Defense spending does not appear to have squeezed out commercial research. The supply of engineers and scientists responds to employment opportunities, and except for a few specialties it is predominantly a commercial labor market. If there are too few professional and technical workers engaged in commercial R&D in the United States, defense spending is not the prime culprit.

States with substantial defense contracts or employment in defense-related industries tend to be states with high proportions of high technology employment -- because most industries with substantial military business are also high technology industries. However, one does not observe a statistically significant association between defense activity and employment in high technology industries that do not depend heavily on defense spending. While Massachusetts and California have relatively large shares of employment in both defense-related industries and more commercially oriented high technology industries, other defense-oriented states have relatively little commercial high tech.

A comparison of the composition of defense-related industries in Massachusetts, California and the small number of other states with substantial representation in both areas reveals that these states tend to have more diverse defense establishments than defense-oriented states lacking commercial high tech. Additionally, an unusually large fraction of defense contract awards in Massachusetts and California goes for research, development, testing and evaluation. Such differences could mean that defense research and procurement activity has fostered high technology development in these states even if it has not in others. However, they also mean that the Massachusetts and California experience is not typical.

In conclusion, there is little evidence that defense spending has had a pernicious effect on innovation in the United States, but also little indication that defense spending provides a general impetus to high technology spinoffs at the state level. While defense may have spurred commercial high tech development in Massachusetts and California, these states are neither typical defense states nor typical high tech states -- even though they are the stereotypes for both.

Endnotes

[1]For a good discussion of these issues, with a different point of view from that presented here, see Tirman (1984).

[2]Given recent concerns about U.S. competitiveness, it is interesting to find that the relationship between defense spending and productivity growth in the 12 countries in Table 1 has weakened over time. If one looks separately at the experience in the 1960s, 1970s and 1980s, one finds a statistically significant negative association between (a) productivity growth in the 1960s -- either GDP per person employed or manufacturing output per hour -- and (b) end-of-decade defense spending relative to GNP. Countries with high defense spending tended to have low rates of productivity growth. For the years 1970 to 1980 the relationship is still negative but does not meet the 5 percent standard for statistical significance. In the 1980s productivity growth slowed in almost every country other than the United States, so that high defense spending relative to GNP was not associated with low rates of productivity growth from 1980 to 1986: The relationships between measures of productivity growth and defense spending in this period are not statistically significant, and in the case of manufacturing output the relationship is positive.

[3]This is not the only way in which defense spending may affect competitiveness. One argument sometimes heard as the Reagan defense buildup got under way ran as follows: defense spending contributes to the federal budget deficit; the deficit causes interest rates to be higher than they would be otherwise; higher interest rates discourage investment spending; and lower investment spending leads to lower productivity growth and reduced competitiveness. The counterargument is that the federal budget deficit is the result of many expenditure and revenue decisions, so that defense should not be singled out for blame. Moreover, even if defense is seen as a major reason for large budget deficits, not everyone agrees that the deficit results in higher interest rates, or that business investment in plant and equipment is very sensitive to interest rates. It appears that the fraction of real GNP devoted to nonresidential fixed investment in 1988 will be a post-World War II record.

Another criticism of defense spending, closer to that considered in this article, is that it occurs at the expense of education and other programs that result in a more productive labor force and, thus, a more competitive economy. For more complete overviews of the effect of defense spending on the U.S. economy, see Adams and Gold (1987) and the U.S. Congressional Budget Office (1983).

[4]The responsiveness of college enrollments to changing economic conditions was illustrated particularly clearly in the 1970s: first-year engineering enrollments dropped sharply in the early 1970s following cutbacks in defense spending and increases in engineering unemployment rates; they then soared in the second half of the decade as commercial demand surged, defense demand stabilized and the engineering labor market tightened. See U.S. Congress, Office of Technology Assessment (1985, p. 93).

[5]Superconductivity is another field thought to have considerable commercial potential, and both Japan and the United States are mounting research efforts. However, in the United States much of the research will be funded by the Department of Defense, which sees implications for the Strategic Defense Initiative as well as commercial opportunities. See the report on Japan's research on superconductors by the Japan Economic Institute (1987).

[6]While political concern for regional equity could limit the extent to which states receiving defense research monies also receive funds for nondefense research, differences in research interests and capabilities are likely to result in trade-offs occurring among states rather than within. Thus, defense research in Massachusetts could come at the expense of medical research in North Carolina or energy research in Texas rather than nondefense research in Massachusetts.

[7]See Hekman and Strong (1981), Malecki (1986) and Warsh (1986).

[8]The list of high tech industries in Table 2 represents something of a consensus; it includes the industries most commonly called high tech without being so broad as to encompass industries for which a high tech designation would strike most readers as inappropriate.

[9]See figures on defense spending by state in the National Journal, May 31, 1986, p. 1319. For the purposes of this article, examining the impact of defense activity on the development of high technology industries, a second drawback to the prime contract data is that they include contracts for various mundane purchases, such as construction, services, uniforms and petroleum, that one would not expect to have much effect, positive or negative, on high technology industries. This is not a major defect, however, as approximately three-quarters of the awards, by value, are for aircraft, ships, electronics and communications equipment, and other "hard goods." Moreover, a criticism sometimes made of the prime defense contract data -- that they are only a partial measure of a state's defense activity because they do not include military payrolls -- is probably an advantage in the present context. One would not expect the presence of a military base, in itself, to be a stimulus to high tech development. While Markusen (1986a) has argued that defense contractors tend to locate near bases, so that a link may run from bases to procurement and to high tech, the prime contract data would capture the second half of the chain.

[10]Had defense-related industries been defined according to the defense share of output in 1985 the list would have included many more traditional industries. However, as described in the text, the large shares of traditional industry output attributable to defense spending were due as much to unusually weak commercial demand as to strong defense demand. Under more normal circumstances, these industries would not be considered defense-related.

[11]The correlation between the two measures of defense orientation has a coefficient of 0.70; the rank order correlation coefficient is 0.67. If SIC 2819 were considered a defense-related industry, the ranking of the states according to the share of employment in defense-related industries would not be very different. The top 10 states would still be the top 10.

[12]The exceptions were Utah, which moved from 12th in 1979 to 7th, and Vermont, which rose from 13th to 8th, replacing Mississippi and Missouri.

[13]Kansas moved from 11th in the earlier period to 8th; Maine slipped from 10th to 13th.

[14]The results in Table 5 are not affected by classifying industrial inorganic chemicals (SIC 2819) as a defense-related industry. In addition, if commercial high tech is expressed as a fraction of private nondefense employment rather than total private employment, the results are still statistically insignificant. In other words, there is not a statistically significant association between state defense activity and commercial high tech employment, measured either as a fraction of private employment or as a fraction of private nondefense employment.

[15]Classifying industrial inorganic chemicals (SIC 2819) as a defense-related industry would reduce chemicals' share of commercial high tech employment. For the nation and for most states the effect is minor. However, it would affect the categorization of several states shown in Table 6. In particular, the defense orientation of Tennessee and South Carolina would be increased and the commercial high tech orientation of these states would be reduced sufficiently to exclude them from the low defense-related, high commercial high tech group. Delaware would not be affected to any noticeable degree and chemicals (excluding both SIC 2819 and SIC 2892) would still be considerably more important in the states with low defense-related and high commercial high tech employment than in the states with high levels of both defense-related and commercial high tech employment.

[16]An exception might arise when the location decision of a large high tech firm alerts other high tech companies to an area's hitherto unappreciated locational advantages.

[17]Missouri received a very large fraction of RDT&E awards in the late 1970s, but through most of the 1980s its share has been roughly in line with employment.

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